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IATA

Controlled Flight Into Terrain Accident Analysis Report

2014-2014

1st Edition

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Section 1—Introduction

The International Air Transport Association (IATA) is dedicated to implementing a data driven approach to the evaluation of aviation safety risks and the development of potential solutions. This Controlled Flight Into Terrain (CFIT) analysis evaluates the risk factors from recent CFIT accidents and presents information designed to aid industry in the implementation of mitigation strategies. Accidents from 2010 through to 2014 were reviewed for this analysis. The data set includes aircraft over 5,700 kg maximum take-off weight that were engaged in commercial operations according to the IATA definition, included in this report. See appendix A for the IATA accident definition used for data in this report.

CFIT refers to accidents in which there was In-flight collision with terrain, water, or obstacle without indication of loss of control. The critical distinction in these types of accidents is the fact that the aircraft is flyable and under the control of the flight crew. There are numerous causal and/or contributing factors of such events. Typically, aircraft malfunction is not the main cause of CFIT accident; rather the accident's probable and immediate causes are often attributed to flight crew or human error, such as non-compliance with established procedures (SOPs), inadequate flight path management, lack of vertical and/or horizontal position awareness in relation to terrain, unstabilized approaches, and failure to initiate a go-around when a go-around was necessary. The absence of precision approaches has also been noted as a factor in CFIT accidents. This report presents the contributing factors categorized into latent conditions in the system, external threats to the flight crew, errors in the handling of those threats and undesired aircraft states resulting from deficiencies in managing these threats or errors. The contributing factors are based on the information available at the time of classification.

Although few in number, CFIT accidents are almost always catastrophic; 91 percent of the accidents involve fatalities to passengers or crew. CFIT, which is the second largest fatal accident category after Loss of Control Inflight (LOC-I), has contributed to 707 of 2,541 fatalities, in the period evaluated. Given this severity, CFIT accidents have been assessed by the IATA Safety Department and the industry to be the second highest risk to aviation safety, and deemed to be an area for increased attention.

This report summarizes the 34 CFIT accidents that occurred during the five (5) years of the period, which resulted in 31 fatal accidents and 707 fatalities.

Section 2–Data Source

This report is focused on the commercial air transport industry; it uses data from Global Aviation Data Management (GADM) accident database over the period of 2010-2014.

Section 3–Exclusions

This report specifically excludes accidents involving the following types of operations:

- Private (general) aviation
- Business or military aviation
- Flights as part of illegal activities
- Humanitarian relief flights
- Crop spraying or other agricultural flights
- Security-related events (e.g. hijackings)
- Experimental or other test flights[1]

Section 4–Scope

This report is intended to provide a detailed understanding of Controlled Flight Into Terrain (CFIT) accident statistics. It provides accident breakdown by aircraft propulsion, by scheduled/unscheduled services, cargo/passenger operations, and rates of occurrence involving jet and turboprop aircraft, as well as IOSA vs. non-IOSA and regional accident rates.

[1] Such as post maintenance functional check flights

Section 5—Global Accident Data

This report was generated from worldwide reports of accidents resulting in hull loss or substantial damage to all jet and turboprop aircraft, greater than 5,700 kg, from January 2010 to December 2014 inclusive.

There were a total of 415 accidents during this period. Of these accidents, 34 were classified as CFIT and form the primary focus for this report. Figure 1 illustrates the global breakdown of accidents across all categories. It should be noted that 409 (99 percent) of the accidents could be assigned an accident category or End State[2]; the remaining six (6) accidents lacked sufficient information for classification.

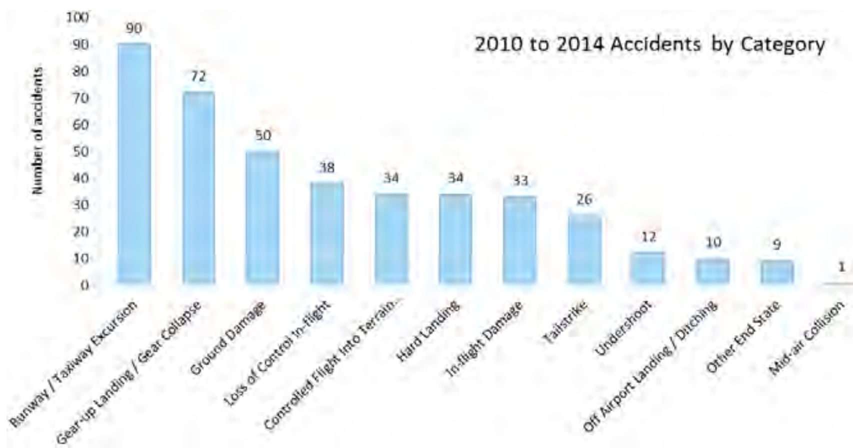

Figure 1: Global Accident Categories Breakdown

Of the total 415 accidents between 2010 and 2014, 88 accidents were fatal resulting in 2,541 total fatalities. The breakdown of fatal accidents by occurrence category is shown in Figure 2. Note that 86 of the fatal accidents were assigned an End State.

CFIT was the second most frequent category of fatal accident representing 31 fatal accidents or 36 percent of total fatal accidents with sufficient information for classification. These CFIT accidents resulted in 707 fatalities among passengers and crew.

[2] An End State is reportable event. An End State is unrecoverable, also known as the Accident Category.

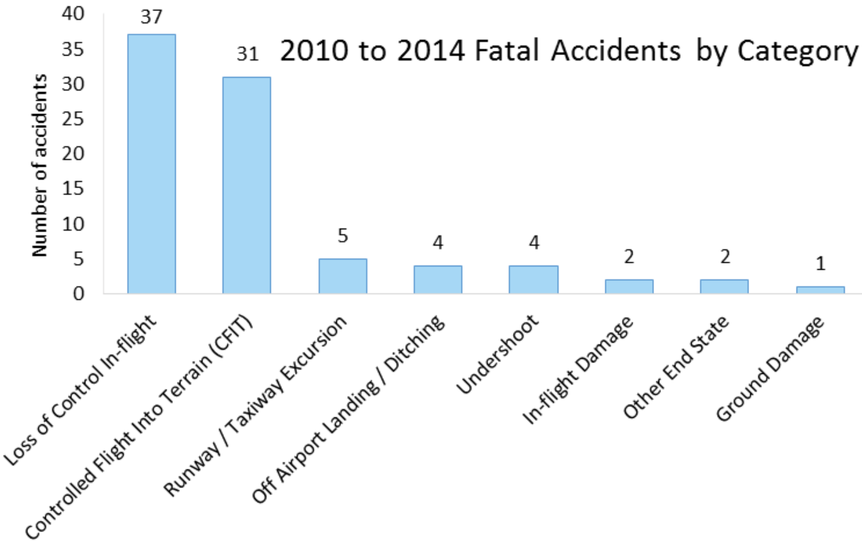

Figure 2: Number of Fatal Accidents per Accident Category

The relative percentage of fatal accidents remained fairly constant from 2010 through 2014, at three to six percent (3 to 6%) of the total number of commercial aircraft accidents. Although the number of commercial aviation fatal accidents fluctuated year to year, the number of fatal accidents that occurred annually between 2010 and 2014 declined overall from 23 to 12. Figure 3 presents the frequency of fatal accidents per year.

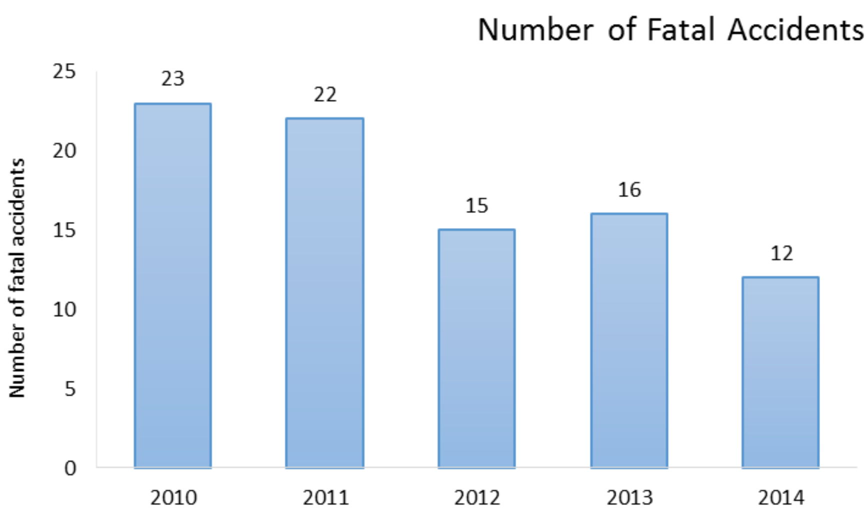

Figure 3: Frequency of Fatal Accidents per Year

CFIT accidents are almost always catastrophic; 91 percent of CFIT accidents between 2010 and 2014 involved fatalities to passengers and/or crew. Over this period, 8.3 percent of all accidents were categorized as CFIT, whereas this category contributed to 28 percent of the total fatalities (707 out of 2,541). Given this disproportionate ratio of fatalities, CFIT accidents represent the second highest risk to life in commercial aviation safety. Figure 4 illustrates the percentage of total accidents and fatal accidents broken down per accident category.

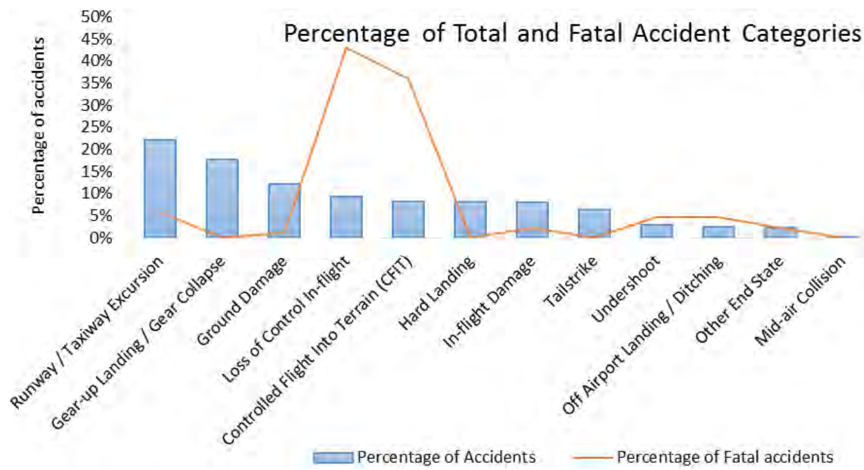

Figure 4: Percentage of Total and Fatal Accidents by Accident Category

Figure 5 presents the concept of high-risk accident categories and was designed to go beyond the traditional method of frequency as the metric for prioritization of mitigation efforts and to establish a priority metric for accident outcome related to survivability.

Each accident category is plotted by the average number of occurrences per year and the percentage of fatalities relative to the total number of people on board. The bubble size increases as the absolute number of fatalities for the category increases; empty bubbles indicate no fatalities for that accident category. From this analysis Loss of Control In-Flight (LOC-I), Controlled Flight Into Terrain (CFIT) and Runway Excursions were identified as the top three high risk categories to be addressed by IATA.

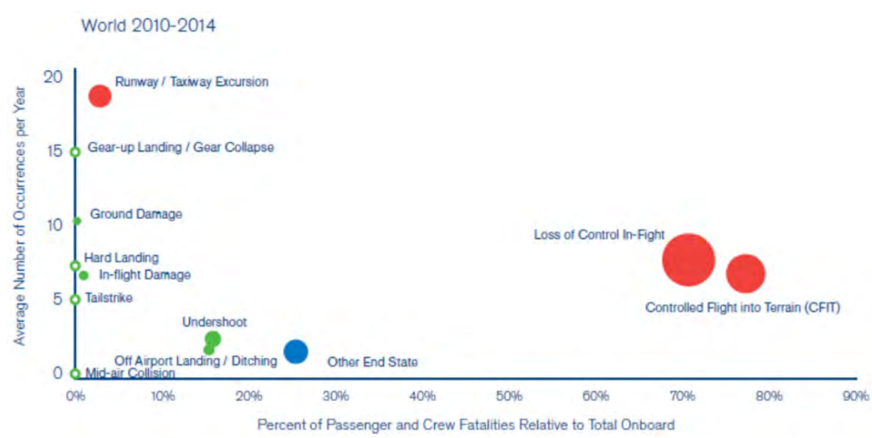

Figure 5: High Risk Accident Category

Table 1 shows that LOC-I was the primary cause of commercial aviation fatalities between 2010 and 2014, followed by Controlled Flight Into Terrain (CFIT)[3]. The improving trends in other accident categories have resulted in LOC-I becoming the leading cause of fatal accidents in air transportation worldwide but it is only recently that LOC-I accidents have overtaken CFIT as the leading fatal accident category. The fact that LOC-I is receiving substantial industry attention despite a relatively low number of accidents is due to the disturbing number of fatalities they have produced. The remainder of this report focuses specifically on CFIT.

Accident Category	Number of Accidents	Fatal Accidents	Fatalities
Loss of Control In-Flight (LOC-I)	38	37	1,242
Controlled Flight Into Terrain (CFIT)	34	31	707
Runway / Taxiway Excursion	90	5	174

Table 1: Top Three Fatal Accident Categories

[3] See Appendix D for additional information on taxonomy-issues

Section 6–Controlled Flight Into Terrain (CFIT) Definition

The definition of Controlled Flight Into Terrain as stated in the IATA Safety Report is an accident in which there is In-flight collision with terrain, water, or obstacle without indication of loss of control.

Section 7—Controlled Flight Into Terrain (CFIT) Accident Data

In the five (5) years covered in this report there were 34 CFIT accidents reported, with an average of 6.8 accidents per year. Figure 6 shows the number of CFIT accidents by year between 2010 and 2014. The highest number occurred in 2011 when there were ten (10) CFIT accidents. The figure of ten (10) accidents was well above the five-year average; however, the last three (3) years of the period showed a decrease in the number of CFIT occurrences and an improvement on the five-year average. It is generally accepted that the reduction in CFIT accidents can be traced back to 1978 when requirements for commercial air transport aircraft to be equipped with the terrain awareness warning system / ground proximity warning system (TAWS/GPWS) were introduced.

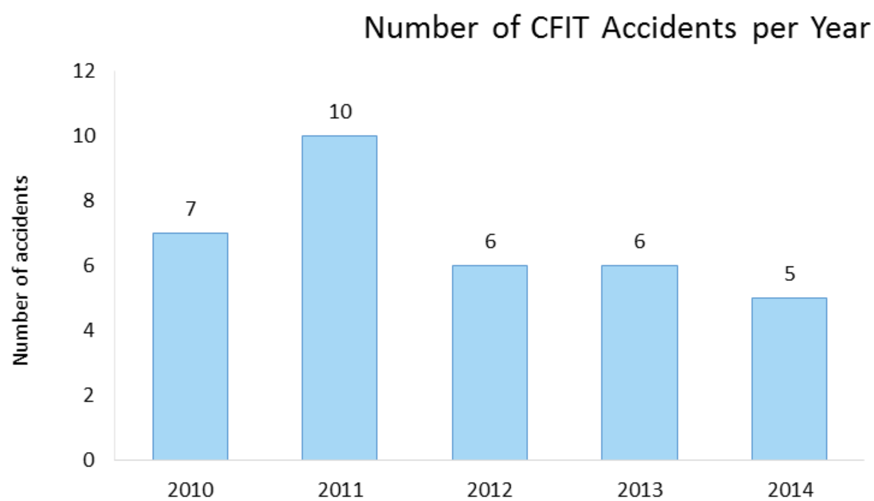

Figure 6: Number of CFIT Accidents per Year

Absolute numbers of accidents are seldom a good indication of safety performance and are of limited comparative value unless they are normalized by the number of sectors[4] flown per year to create an accident rate. Figure 7 shows the CFIT accident rates per million sectors flown each year. Although there is an improving trend in this category, CFIT accidents have been and continues to be a dominant category of accidents involving hull losses and fatalities.

[4] IATA defines “sector” as the operation of an aircraft between takeoff at one location and landing at another location (other than a diversion).

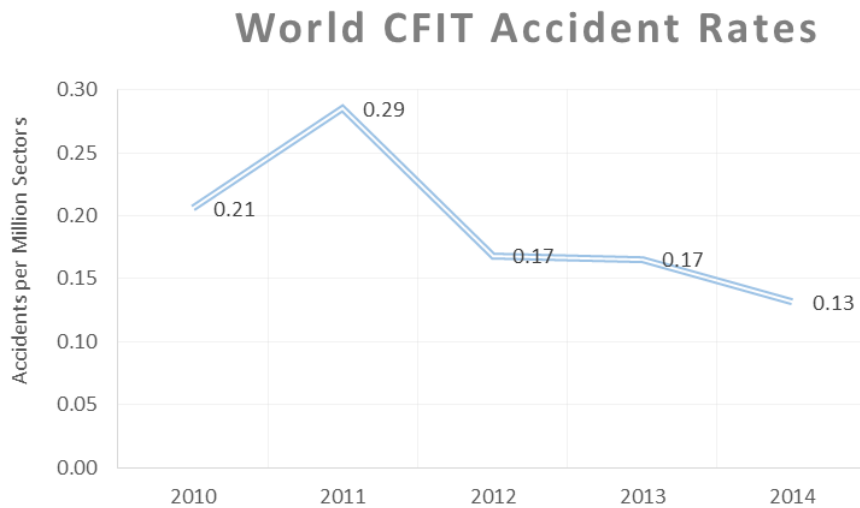

Figure 7: CFIT Accident Rates per Million Sectors

7.1 Controlled Flight Into Terrain (CFIT) by Aircraft Propulsion

This section breaks down the CFIT total accidents and the accident rates per million sectors flown by each aircraft propulsion type. Over the five (5) years jet aircraft were involved in 11 CFIT accidents or 32 percent of the total, while turboprop aircraft were involved in 23 accidents or 68 percent of the total. The annual average for commercial jet CFIT accidents is about two (2) per year, whereas for turboprops it is approaching five (5) per year. Figure 8 illustrates the distribution of CFIT accidents per aircraft propulsion each year.

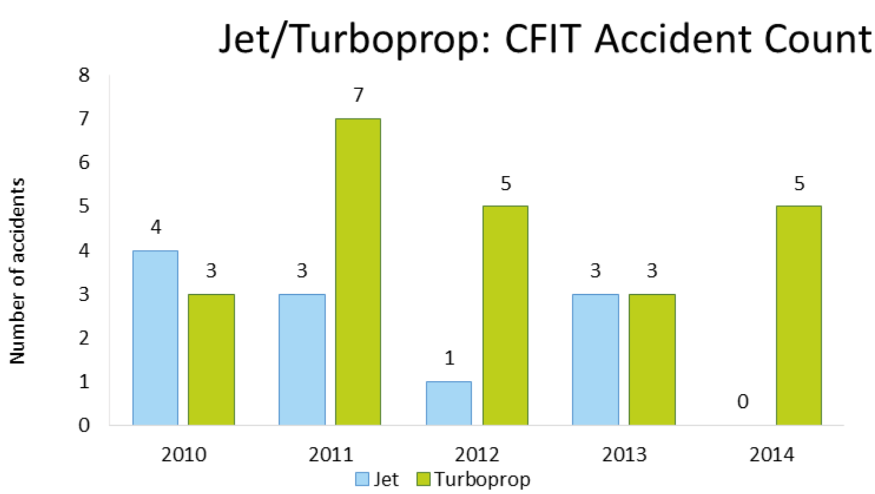

Figure 8: Distribution of Jet and Turboprop Aircraft CFIT Accident Count

Turboprop aircraft also had a higher average rate of CFIT accidents than jet aircraft at 0.63 accidents per million sectors as opposed to 0.08. Figure 9 illustrates the distribution of accident rates per year broken down by turboprop and jet propulsion.

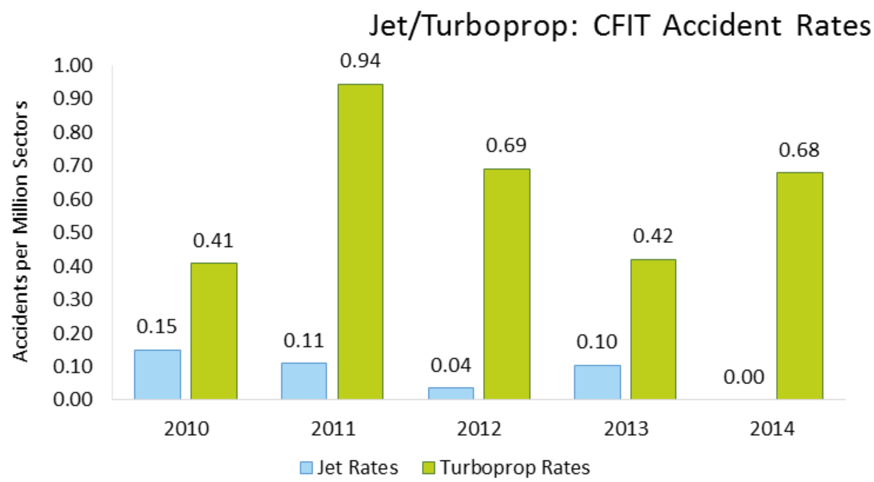

Figure 9: Distribution of Jet and Turboprop Aircraft CFIT Accident Rates

7.2 Controlled Flight Into Terrain (CFIT) Severity

CFIT accidents tend to be severe in terms of number of fatalities and extent of damage to the airframe. Of the 34 total CFIT accidents from 2010-2014, 100 percent resulted in a hull loss and 91 percent (31 accidents) resulted in fatal accidents including one or more fatalities among the passengers or crew. This accident category has become the third highest cause of hull losses with 20.6 percent of total commercial aircraft losses during the period 2010 to 2014. Figure 10 illustrates CFIT hull loss and fatal CFIT accidents for all aircraft between 2010 and 2014. It is worth noting that all CFIT accidents in 2012 and 2013 were fatal.

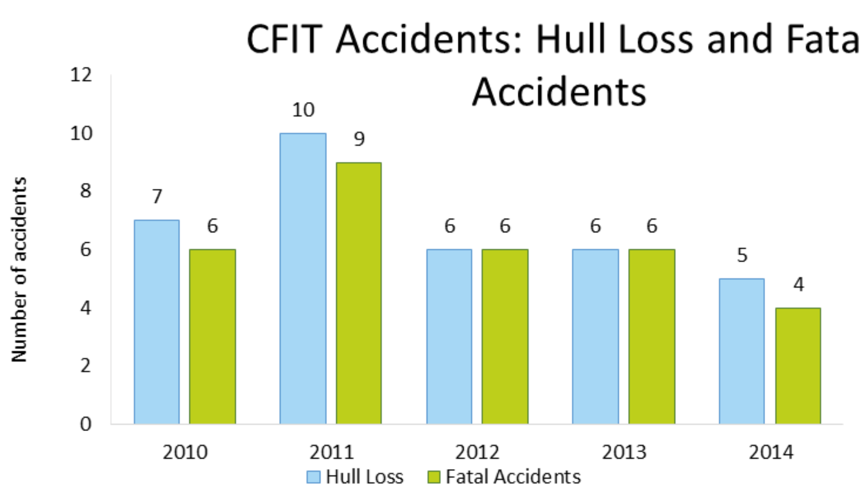

Figure 10: Hull Loss and Fatal CFIT Accidents

When the 31 CFIT fatal accidents were broken down by aircraft propulsion, turboprop aircraft had a significantly higher average rate of fatal accidents (0.57 per million sectors vs. 0.07 for jet); figure 11 illustrates the breakdown of the rates of fatal accidents by aircraft propulsion per year.

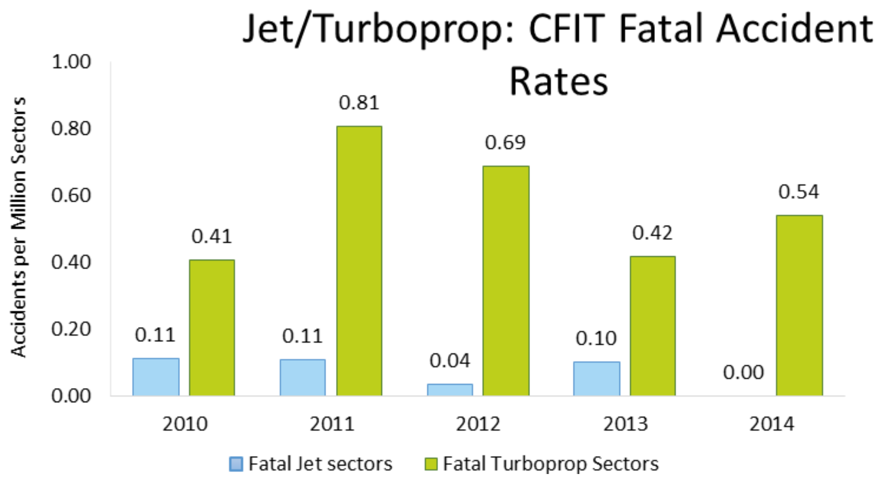

Figure 11: CFIT Fatal Accidents by Aircraft Propulsion per Year

Although turboprop aircraft had a higher number of fatal CFIT accidents, jet aircraft had a higher number of actual fatalities (422 fatalities vs. 285 for turboprop); this primarily reflects the capacity differential between jet and turboprop aircraft. Table 2 presents the CFIT fatal accidents, accident rates and the number of fatalities per aircraft propulsion.

	Jet fatal accidents	Jet fatal accident rates	Jet fatalities	Turboprop fatal accidents	Turboprop fatal accident rates	Turboprop fatalities
2010	3	0.11	297	3	0.41	63
2011	3	0.11	68	6	0.81	86
2012	1	0.04	1	5	0.69	64
2013	3	0.10	56	3	0.42	9
2014	0	0.00	0	4	0.54	63

Table 2: CFIT Fatal Accident Rates and Fatalities per Aircraft Propulsion

It can be useful to understand how many people onboard survived a fatal accident. The survivability percentage, comparing the number of people who survived with the total number of people onboard, can be indicative of the relative severity of fatal accidents. Table 3 presents the CFIT fatal accident count, the number of fatalities and survivability by aircraft propulsion.

Class	Fatal Accident Count	Fatalities	Survivability
Jets	10	422	19%
Turboprops	21	285	8%

Table 3: CFIT Fatal Accident Count and Survivability by Aircraft Propulsion

7.3 IOSA Registered Carriers Versus Non-IOSA Registered Accident Rate

The IATA Operational Safety Audit (IOSA) program is an internationally recognized and accepted evaluation system designed to assess the operational management and control systems of an airline. All IATA members are IOSA registered and must remain registered to maintain IATA membership. Many non-IATA member carriers are now opting to become IOSA registered.

The positive results of IOSA are demonstrated when the ‘all accident’ rate is broken-down to show the rate for IOSA registered airlines compared to the rate for operators not on the IOSA registry. The overall accident rate for IOSA-registered airlines is just over a third of that for non-IOSA-registered airlines for the period between 2010 and 2014. Table 4 shows the IOSA versus the Non-IOSA registered accident rates.

Category	2010	2011	2012	2013	2014	Average 2010-2014
All Accident	2.77	2.63	2.11	2.24	1.92	2.33
IOSA	1.75	1.78	1.06	1.48	1.09	1.43
Non-IOSA	4.73	4.36	3.94	3.53	3.32	3.98

Table 4: IOSA Versus Non-IOSA Registered Accident Rates

The positive results are reinforced when the CFIT fatal accident rate is broken-down to show the rate for IOSA registered airlines compared to the rate for operators not on the IOSA registry. The overall accident rate for IOSA-registered airlines was less than one tenth of that for non-IOSA-registered airlines for the period between 2010 and 2014. Figure 12 shows the worldwide fatal CFIT accident rates in comparison to IOSA versus the Non-IOSA registered CFIT fatal accident rates.

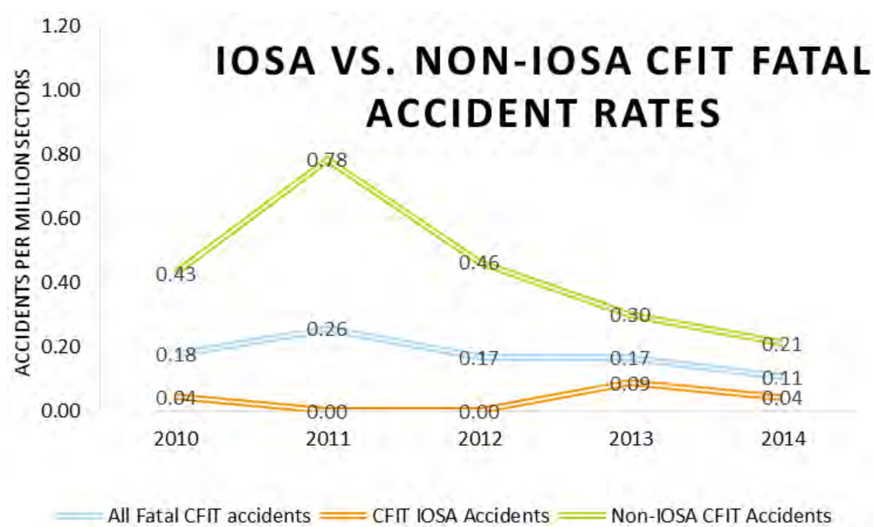

Figure 12: IOSA Versus Non-IOSA CFIT Fatal Accident Rates

IOSA demonstrated a further positive effect on aviation safety, when comparing jet and turboprop safety performance in terms of CFIT fatal accidents. In Table 5 the global CFIT fatal accident rate is broken-down to show the CFIT fatal accident rates of the different types of aircraft propulsion in relation to IOSA versus non-IOSA registered operators.

Category	2010	2011	2012	2013	2014	Average 2010-2014
Fatal Accidents – Jet	0.11	0.11	0.04	0.10	0.00	0.07
IOSA – Jet	0.05	0.00	0.00	0.10	0.00	0.03
Non-IOSA – Jet	0.30	0.47	0.12	0.12	0.00	0.19
Fatal Accidents –Turboprop	0.41	0.81	0.69	0.42	0.54	0.57
IOSA – Turboprop	0.00	0.00	0.00	0.00	0.19	0.04
Non-IOSA –Turboprop	0.59	1.19	1.02	0.60	0.57	0.79

Table 5: CFIT Fatal Accident Rates for Operators of Turboprop and Jet Aircraft on the IOSA Registry Versus Non-IOSA Registry

The following section provides insight into the type of operational service in relation to CFIT accidents by breaking them down into scheduled/unscheduled and cargo/passenger services for all aircraft categories.

7.4 Impact of Operational Service Types

Different operational service types and/or the familiarity of the operational environment can affect the potential for a CFIT accident. This section presents the type of operational service, in terms of cargo/passenger operations and scheduled/unscheduled operations. Two (2) accidents or six (6) percent of CFIT accidents involved ferry flights. The majority with 20 accidents or 59 percent of all CFIT accidents involved passenger flights, while cargo flights sustained 12 accidents or 35 percent of the total.

Of the 20 CFIT accidents to passenger services, 19 accidents were fatal, resulting in 655 fatalities and a 14 percent survivability rate. Of the 12 CFIT accidents to cargo flights, 11 were fatal, resulting in 50 fatalities with an eight (8) percent survivability rate.

Of the 19 fatal CFIT accidents during passenger service, 17 accidents or 89 percent were operating domestic flights and two (2) accidents or 11 percent were engaged in international operations. Of the 11 fatal accidents during cargo flights, eight (8) accidents or 73 percent were operating domestic flights and three (3) or 27 percent of those accidents were to aircraft engaged in international operations. Of the two (2) CFIT accidents to ferry flights, one (1) was fatal. Table 6 presents the summary of fatal CFIT accidents by type of operational service.

Service	Total fatal accidents	Domestic flights	International flights
Passenger	19	17	2
Cargo	11	8	3
Ferry	1		

Table 6: CFIT Fatal Accidents by Types of Service[5]

[5] The higher number of passenger CFIT accidents reflects the high volume of flights in this category

When the CFIT accidents were broken down by scheduled and non-scheduled operations, it was apparent that scheduled passenger operations had a higher number of accidents (almost by a factor of 5) compared to the non-scheduled passenger operations, while the scheduled cargo operations had a CFIT accident factor almost three (3) times lower than non-scheduled cargo operations. Table 7 summarizes the number of CFIT accidents by scheduled vs. non-scheduled operations.

Service	All	Fatal	Fatalities	Survivability
Passenger				
Scheduled	17	16	593	17%
Non-scheduled	3	3	62	0%
Cargo				
Scheduled	1	1	2	0%
Non-scheduled	11	10	48	9%

Table 7: CFIT Accidents by Scheduled Versus Non-Scheduled[6]

Table 8 breaks down the fatal CFIT accidents by phase of flight and type of operational service. Note that the percentage shown summarizes the proportion of the fatal accidents for the phases of flight compared to the total number of fatal accidents for each of the types of operational service.

Phase of Flight	Passenger count	Passenger percentage	Cargo count	Cargo percentage
ICL	0	0%	4	36%
CRZ	3	16%	1	9%
DST	0	0%	1	9%
APR	11	58%	5	46%
GOA	2	10%	0	0%
LND	3	16%	0	0%

Table 8: Distribution of Flight Phase by Service Type for Fatal CFIT Accidents

[6] The higher number of scheduled passenger CFIT accidents reflects the high volume of flights in this category

Figure 13 illustrates the percentage of the phase of flight associated with the total number of fatal accidents involved with each of the different types of operational service.

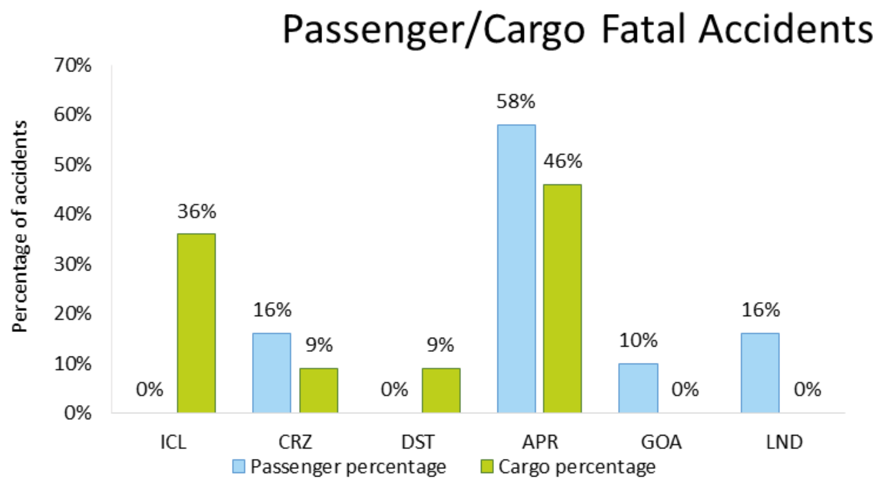

Figure 13: Percentage of CFIT Fatal Accidents in Each Flight Phase by Type of Service

7.5 Controlled Flight Into Terrain (CFIT) Accidents by Flight Phase

Analysis shows that CFIT accidents happen during most phases of flight but the greatest risk is during the approach phase with 18 accidents or 53 percent of the total. Of those accidents only one (1) was non-fatal. Distribution of fatal and non-fatal CFIT accidents by flight phase is illustrated in figure 14.

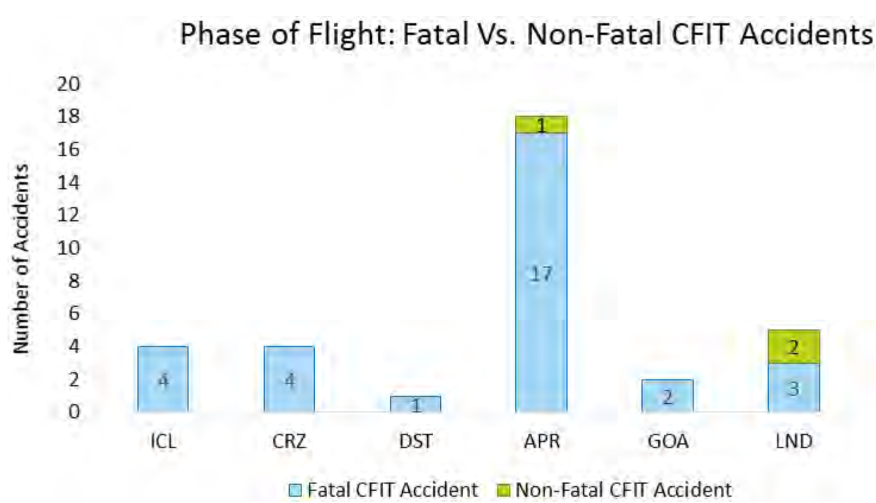

Figure 14: Fatal Versus Non-Fatal CFIT Accidents by Phases of Flight

The definitions for each flight phase used in this report are presented in Appendix A.

CFIT fatal accidents at various phases of flight were broken down into jet or turboprop aircraft propulsion and the distribution is illustrated in Figure 15. It was noted that there were zero (0) jet fatal accidents in the initial climb (ICL) and go-around (GOA) phases of flight and zero (0) turboprop fatal accidents in the descent (DST) phase of flight.

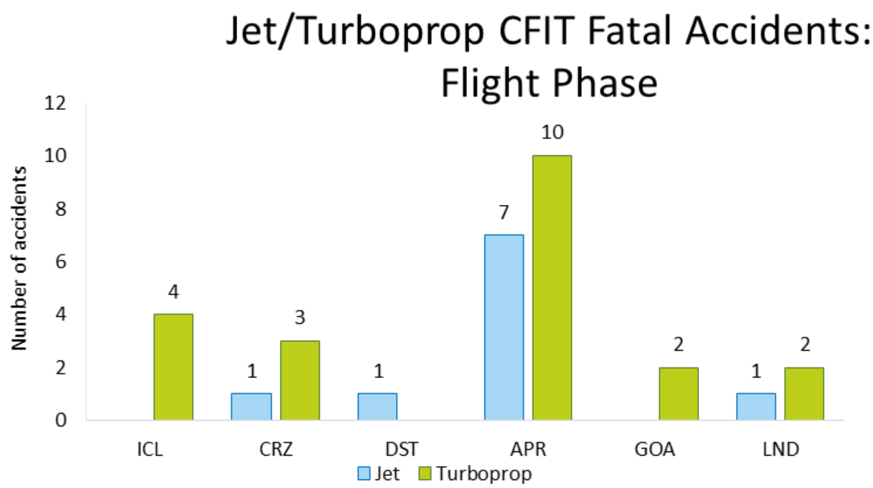

Figure 15: Distribution of Jet Versus Turboprop Fatal CFIT Accidents by Phases of Flight

7.6 Controlled Flight Into Terrain (CFIT) Regional Analysis

The following section presents an analysis of the regional differences in CFIT accidents. Global regions are defined by IATA; the breakdown of regions and constituent countries is listed in Appendix B.

Figure 16 presents the overall distribution of CFIT accidents by region of operator. Operators from Commonwealth of Independent States (CIS) witnessed the greatest number with eight (8) accidents, or 24 percent of the total CFIT accidents, followed by operators from Africa (AFI) with seven (7) accidents or 21 percent of the total. Operators from Asia Pacific (ASPAC) were involved in six (6) accidents, or 18 percent of the total. North American (NAM) operators were involved in five (5) accidents or 15 percent of the total. Operators from Latin America & the Caribbean (LATAM/CAR) and Middle East and North Africa (MENA), were involved with three (3) accidents each, or nine (9) percent of the total. Operators from North Asian (NASIA) had two (2) CFIT accidents, or six (6) percent of the total. European operators had zero (0) accidents in the time period studied.

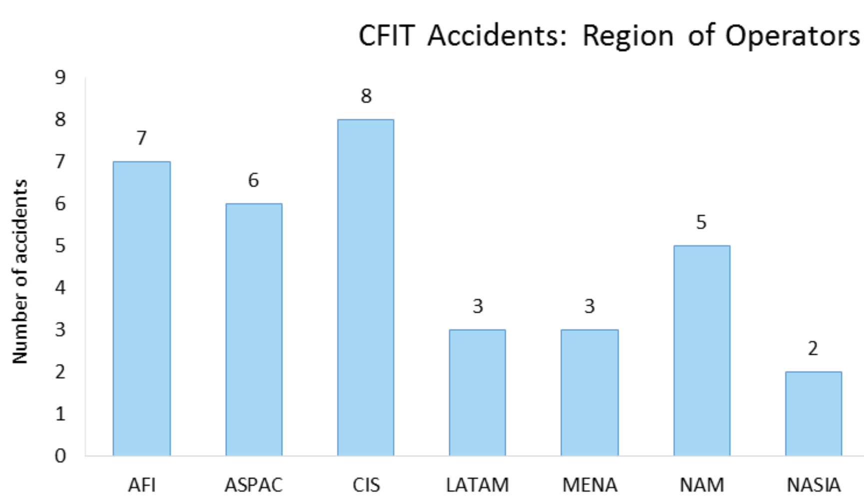

Figure 16: CFIT Accidents by Region of Operator

It is apparent that CFIT accidents are occurring mainly in areas of the world where the use of TAWS / GPWS is not universally mandatory. It is recommended that these states mandate the use of TAWS/GPWS in commercial air transport aircraft as it demonstrates a clear benefit for CFIT reduction. TAWS/GPWS requires aircraft to be equipped with accurate navigation systems like global positioning system (GPS) for both navigation and terrain surveillance. Such systems are available for most commercial air transport aircraft in operation today.

Figure 17 illustrates the CFIT accident rates per million sectors flown based on the region of operator. Operators from AFI had the highest rate of CFIT accidents, with a 1.40 per million sectors flown. Operators from EUR had the lowest rate with zero (0) CFIT accidents.

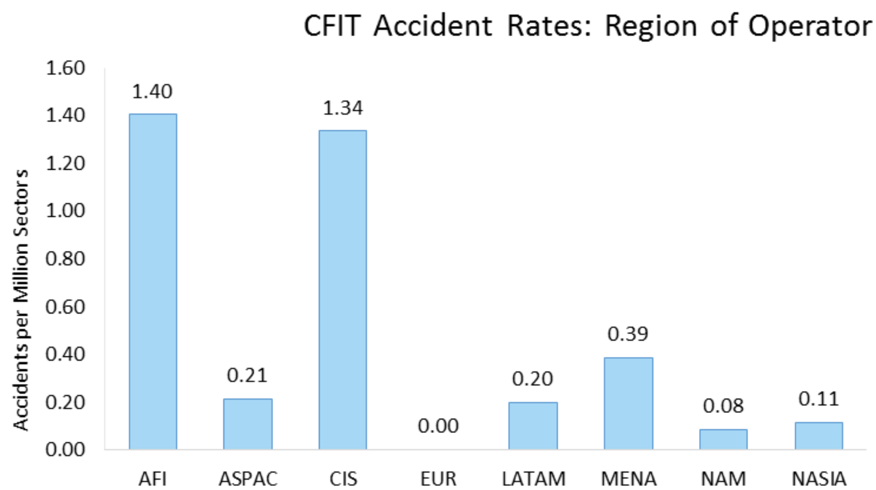

Figure 17: CFIT Accident Rates by IATA Region of Operator

A comparison of the total CFIT accidents versus the fatal ones in respect to each of the IATA global regions shows that all accidents involving operators from ASPAC, LATAM, MENA, NAM and NASIA were fatal. Figure 18 illustrates the distribution of fatal accident rates per region of operator.

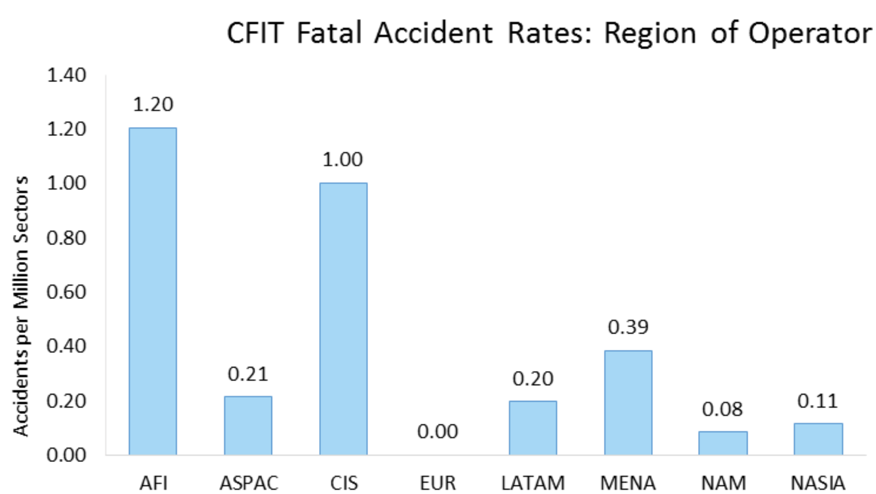

Figure 18: CFIT Fatal Accident Rates by Region of Operator

Figure 19 presents the number of CFIT fatal accidents in each region broken down by type of operational services; passenger or cargo. The largest discrepancy in operational service type was for NAM and AFI operators where cargo operations represented a higher number of fatal CFIT accidents. MENA and ASPAC operators only had fatal accidents involving passenger services. AFI had one (1) fatal accident involving ferry flight.

A detailed sector breakdown by passenger or cargo operations was not available for this analysis. Without sector information, the configuration of the world fleet can be used to make some estimates of the exposure. At the end of 2014, 25,494 aircraft were configured for passenger operations while 3,474 were configured for cargo operations (this includes: all cargo, mixed passenger/cargo or quick change configurations). Based on this we can calculate an accident rate per 1,000 aircraft. Cargo configured aircraft had a higher incidence of CFIT accident per 1000 aircraft (5.18 per 1,000 aircraft compared to 2.12 for passenger).

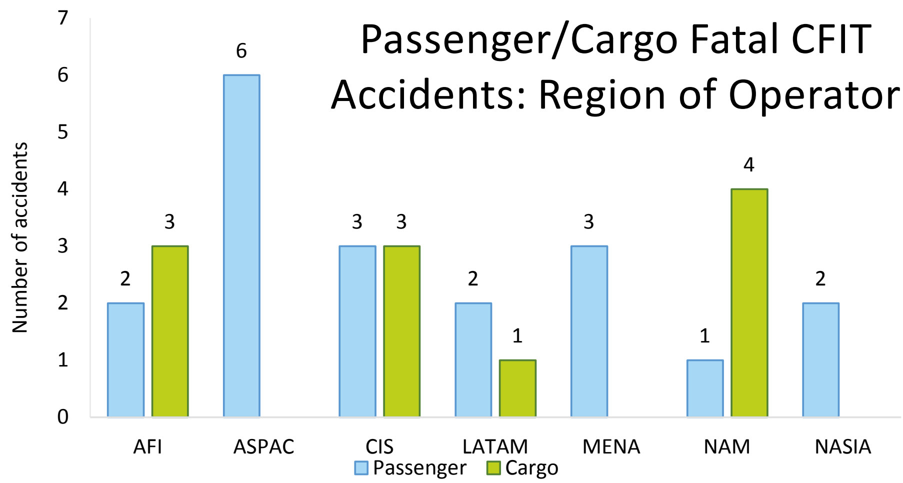

Figure 19: Distribution of CFIT Fatal Accidents by Service Type and Region of Operator

7.7 Controlled Flight Into Terrain (CFIT) Accidents by Regional Aviation Safety Group (RASG) Regions

A harmonized regional analysis is also provided using the ICAO Regional Aviation Safety Group regions. Full breakdown of the five (5) RASG regions are at Appendix C. The number of accidents and normalized accident rates during the same period by RASG region are shown in this section.

Figure 20 illustrates the distribution of CFIT accidents by RASG Region of operator during the period.

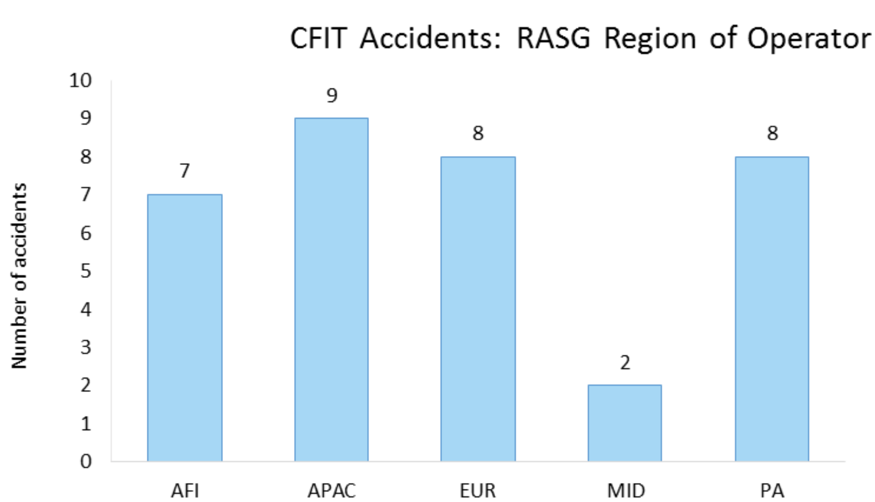

Figure 20: CFIT Accidents by RASG Region of Operator

Figure 21 illustrates the distribution of CFIT accident rate per million sectors flown per RASG region of operator.

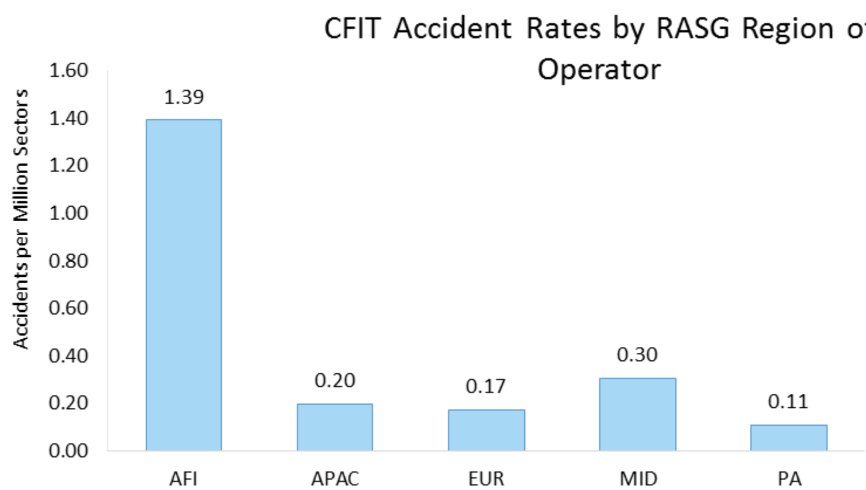

Figure 21: CFIT Accident Rates by RASG Region of Operator

This report includes a worldwide comparison of fatal and non-fatal CFIT accidents by RASG region of operator. It was apparent that there were three (3) non-fatal accidents, one (1) of which involved Africa-Indian Ocean (AFI) RASG region of operator and two (2) involved European (EUR) based RASG region of operator. Figure 22 illustrates the distribution of fatal and non-fatal CFIT accidents by RASG region of operator.

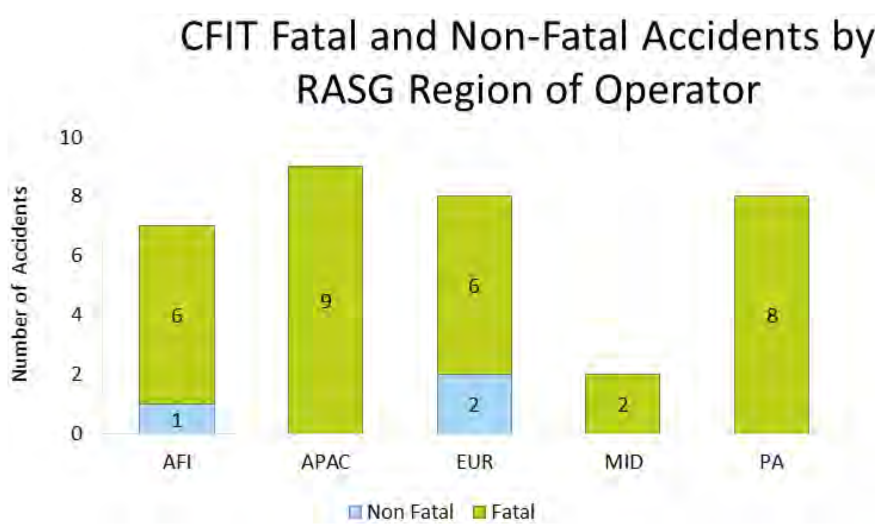

Figure 22: Distribution of Fatal and Non-Fatal CFIT Accidents by RASG Region of Operator

This report also includes a worldwide RASG comparison of fatal CFIT accident jet and turboprop powered aircraft. Figure 23 illustrates the RASG regional fatal CFIT accidents by aircraft propulsion.

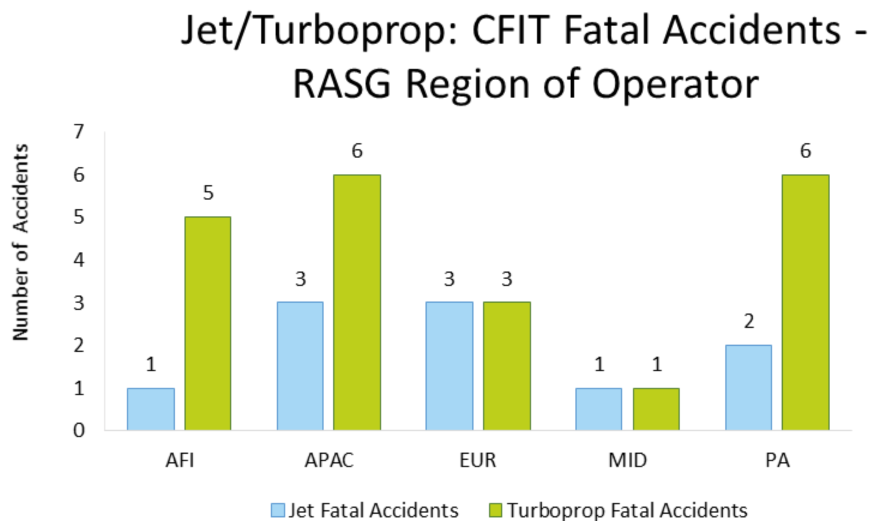

Figure 23: RASG Regional Fatal CFIT Accidents by Aircraft Propulsion

Figure 24 illustrates the different aircraft propulsion fatal accident rates per million sectors flown based on the RASG regions of operator.

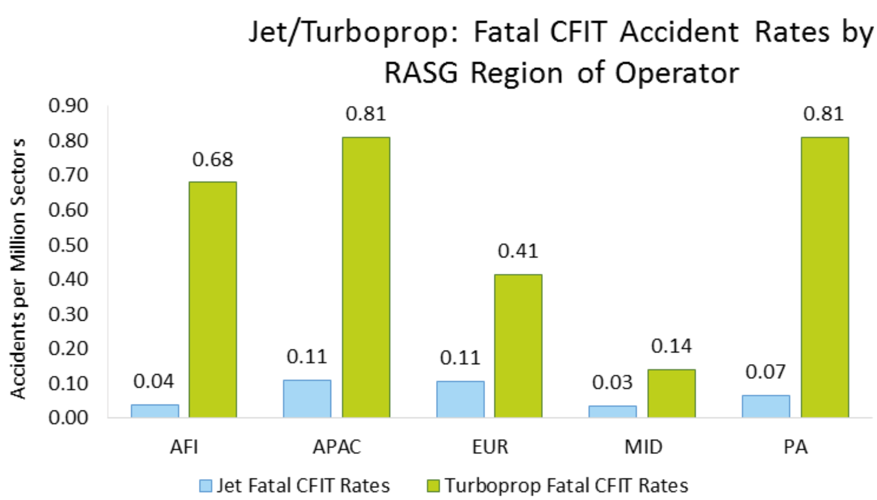

Figure 24: CFIT Fatal Accident Rates by RASG Region of Operator and Aircraft Propulsion

Typically in CFIT accidents, as in any aviation accidents generally, there is a series of contributing factors that may lead to an accident, a chain of human errors, meteorology, poor visibility/IMC, ground-based nav-aid malfunction or not available, regularity oversight, aids, etc... The following section provides insight into the contributing factors to CFIT accidents. These contributing factors include latent conditions in the system, external threats to the flight crew, errors in the handling of those threats and undesired aircraft states from deficiencies in managing these threats or errors.

7.8 Controlled Flight Into Terrain Contributing Factors

IATA, through the Accident Classification Task Force, assigns contributing factors to accidents to better understand the correlations. All CFIT accidents from 2010 to 2014 were classified. The world most frequent contributing factors are shown in Figure 25.

Latent Conditions (deficiencies in...)	
Regulatory Oversight	56%
Technology & Equipment	47%
Safety Management	32%
Flight Operations	21%
Flight Ops: Training Systems	15%
Environmental Threats	
Meteorology	44%
Ground-based nav aid malfunction or not available	41%
Nav Aids	41%
Poor visibility / IMC	38%
Terrain / Obstacles	18%
Airline Threats	
Aircraft Malfunction	3%
Autopilot / FMS	3%
Avionics / Flight Instruments	3%
Maintenance Events	3%
Operational Pressure	3%

Flight Crew Errors (related to…)	
SOP Adherence / SOP Cross-verification	38%
Intentional	26%
Unintentional	12%
Callouts	15%
Manual Handling / Flight Controls	15%
Undesired Aircraft States	
Controlled Flight Towards Terrain	41%
Vertical / Lateral / Speed Deviation	41%
Unnecessary Weather Penetration	12%
Unstable Approach	6%
Long/floated/bounced/firm/ off-center/crabbed land	3%
Countermeasures	
Monitor / Cross-check	38%
Overall Crew Performance	35%
Communication Environment	12%
Leadership	12%
Plans Stated	12%

Figure 25: World Most Frequent CFIT Contributing Factors

The contributing factors follow a Threat and Error Management structure and are divided into the following four areas:

- Latent Conditions: underlying issues in the system before an accident
- Environmental and Airline Threats: events outside the control of the flight crew that must be managed to ensure margins of safety are maintained
- Flight Crew Errors: errors in the management of threats that reduce margins of safety
- Undesired Aircraft State: flight-crew induced aircraft state(s) that reduces safety margins. The undesired aircraft state is recoverable.

In some cases there are sub-categories of contributing factors, these are displayed as darker colors in the chart for the category and a lighter hue of the same color for the sub-category. It is possible for one event to have more than one sub-category; in this case the total of the sub categories will equal more than the total for the category.

Latent conditions are typically difficult to derive unless very detailed information is available. Accident Classification Task Force (ACTF) derives Latent Conditions by looking at IOSA-results and any earlier safety issues that might have been identified. Also, the question is asked 'What risk mitigation strategies would likely have prevented the accident?', e.g. more stringent regulatory oversight, the provision of a Safety Management System (SMS) or training.

The main contributing factors in Latent Conditions, as shown in figure 26, were deficiencies in the implementation of SMS at the operator, insufficient regulatory oversight, and weak training standards in flight operations.

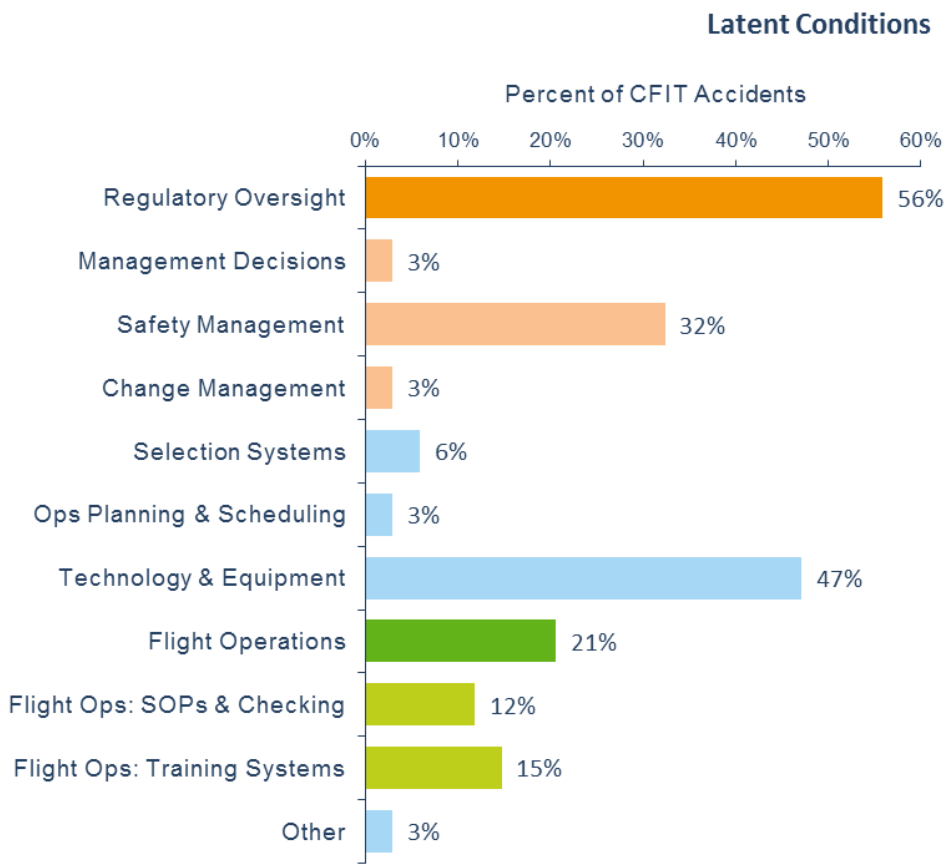

Figure 26: Latent Conditions Contributing to CFIT Accidents

Events outside of the influence of the flight crew that have the potential to reduce the safety margins of a flight are considered Threats. These require crew attention and management to ensure the continued safety of the flight.

In the Environmental and Airline Threats contributing factors, meteorology, the presence of a malfunctioning or non-existent ground-based nav-aid equipment, terrain and obstacles, the reduced visibility associated with instrument meteorological conditions (IMC), Air Traffic Services, or a combination of the latter two conditions were cited as a causal factor to CFIT accident. Figure 27 indicates the most common environmental and airline-related threats associated with CFIT accidents.

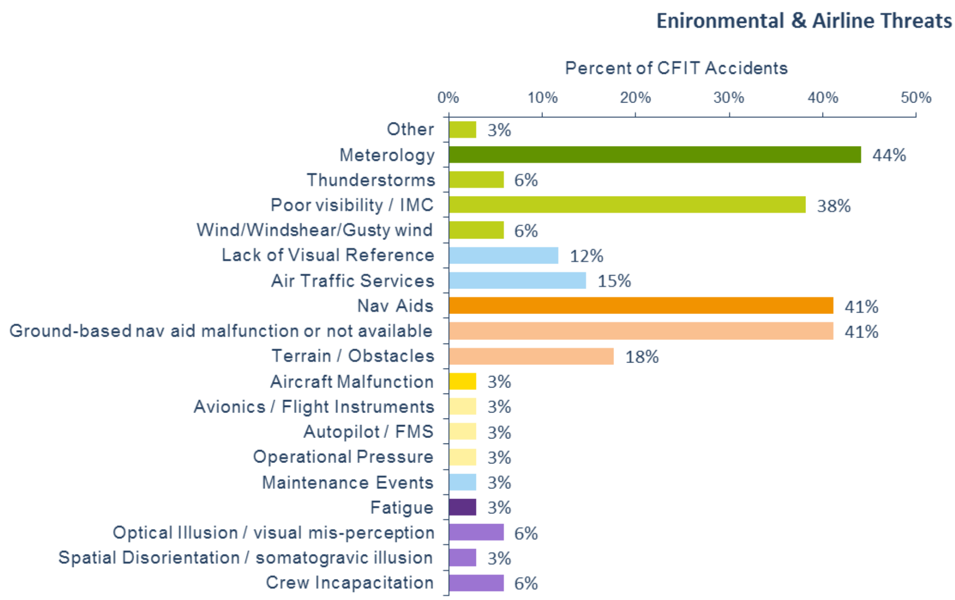

Figure 27: Environmental and Airline Threats Contributing to CFIT Accidents

It is worth noting that 73 percent of the jet CFIT accidents occurred in poor visibility conditions, while the turboprop rate stood at 32 percent. 75 percent of the turboprop CFIT accidents involved aircraft without safety technology such as E-GPWS, or predictive wind-shear warning systems, whereas the jet rate stood at 37 percent.

If a threat is not managed correctly it can lead to an error. These errors are defined as observed flight crew deviations from organizational expectations or flight crew intentions. Figure 28 illustrates the contributing factors related to the Flight Crew Errors category. Factors such as aircraft handling, procedural or communication errors, insufficient horizontal or vertical situational awareness, and non-adherence to Standard Operating Procedure (SOP) by the flight crew were cited as contributing factors to CFIT accidents.

Flight crew situational awareness includes the accurate perception by flight crew of the factors and conditions currently affecting the safe operation of the aircraft, and their lack of vertical and/or horizontal position awareness in relation to the ground, water, or obstacles.

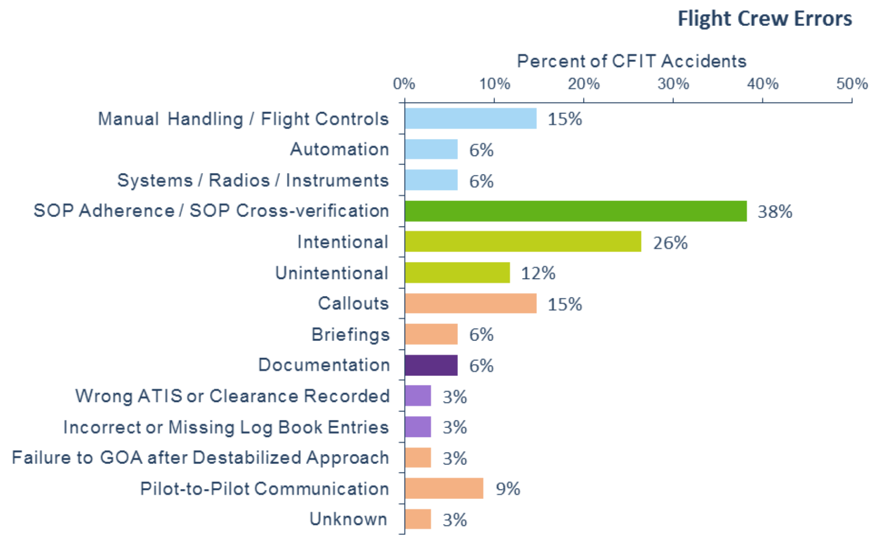

Figure 28: Flight Crew Errors Contributing to CFIT Accidents

Mis-managed errors can lead to additional errors or undesired aircraft states. These are flight crew-induced states that clearly reduce safety margins. Undesired aircraft states are still recoverable. Figure 29 illustrates the undesired aircraft states that are associated with the CFIT accidents analyzed in this report. Vertical, lateral or speed deviations and unnecessary weather penetration were cited as contributing factors in the approach phase of flight. Unstable approaches also contribute to CFIT accidents or incidents. Unstable approaches increase the possibility of diverting a flight crew's attention away from the approach procedure to regain better control of the airplane. Stabilized approach policies broadly concur in stating that a safe approach requires the flight path angle, configuration, and airspeed to be stabilized. Once one or more of these parameters are violated, the approach becomes unstable and the margin for a safe landing is decreased to a level requiring flight crew action; a go-around should be initiated.

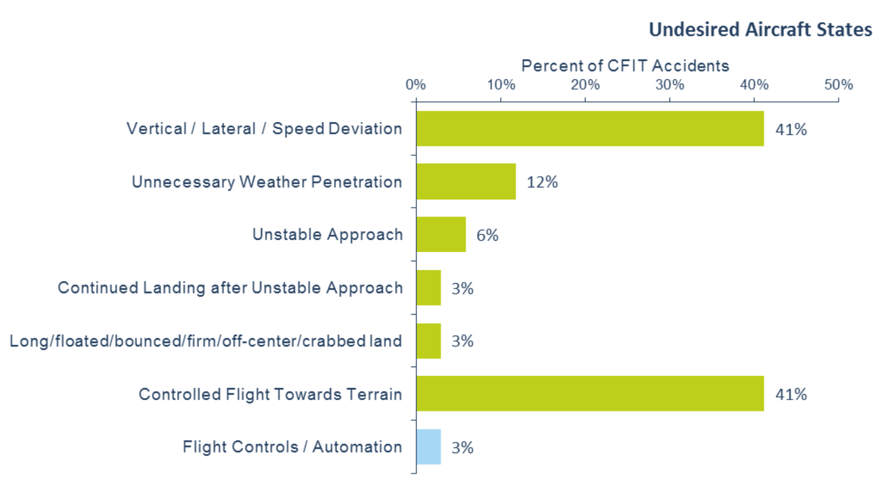

Figure 29: Undesired Aircraft States Contributing to CFIT Accidents

Improved monitoring and cross-checking were found to be methods that could have prevented many of the accidents, while a better display of leadership could have positively affected 32% of the accidents. The following section addresses the mitigation strategy.

7.9 Mitigation of CFIT Accidents

Effective CFIT accident risk mitigation strategies broadly fall into three (3) categories: Human; Procedural, and; Technological.

The available Human mitigations involve improving and maintaining pilots' knowledge, their awareness and their competence, and each of these can be achieved by a comprehensive training program embracing classroom, simulator and flight training. Pilots' knowledge of aircraft systems, aircraft performance and normal/abnormal procedures is vital to ensure that they do not find themselves in unexpected situations from which they cannot immediately recover. Pilots must also be keenly aware of the risks of CFIT, the circumstances in which those risks are greatest and the best strategies for maintaining an accurate picture of their horizontal and vertical situation. Finally, pilots' competence in recognizing and responding to potential CFIT must be realistically trained and tested in recurrent simulator training sessions, using examples from operational experience.

Procedural CFIT mitigations include effective and straightforward actions to initiate and fly the CFIT escape maneuver but they go deeper than that into the safety management and training systems of the operator. The Safety management systems (SMS) must incorporate management procedures to constantly review and assess the CFIT risk exposure to the operation in order to ensure that the risk is as low as reasonably practicable (ALARP) and tolerable. Operational procedures can also provide CFIT risk mitigations by avoiding non-precision approaches especially in high risk destinations or adopting risk reducing strategies such as continuous angle NPAs or performance based navigation (PBN) approaches.

Technological CFIT mitigations primarily rely upon the TAWS/GPWS equipment, which in the latest generations provides pilots with real time terrain information not only below the aircraft but all around it with installations like enhanced ground proximity warning system (EGPWS) and forward looking terrain awareness (FLTA). Such equipment, referred to by ICAO as 'GPWS which has a forward looking terrain avoidance capability', is available for most aircraft in service today and it should be mandated and adopted in all regulatory jurisdictions in accordance with ICAO standards (Annex 6 Part 1). In order to be effective it is essential that the aircraft system hardware and firmware are correctly maintained and that the software database is properly updated. Vertical situation displays in the cockpit are becoming more common and these provide pilots with an easy to assimilate picture of the terrain profile ahead of the aircraft, together with its projected vertical flight path.

7.10 Accident Scenarios of Interest

Some likely scenarios leading to CFIT accidents are:

SCENARIO 1:

Deficiencies in the regulatory oversight of the operator; flight crew flying a non-standard instrument procedure; aircraft not equipped with a terrain awareness warning system (TAWS/GPWS). The aircraft subsequently impacts terrain.

SCENARIO 2:

Deficiencies in the operator's SMS; the crew intentionally disregard SOPs; the aircraft is flown towards the ground until impact.

SCENARIO 3:

Deficiencies in the operator's flight crew training system; the crew intentionally disregards SOPs; the aircraft enters a state of vertical, lateral, or speed deviation during approach or landing (unstable approach); aircraft consequently impacts the ground.

SCENARIO 4:

Approach to an airport with absent or non-functioning ground-based navigation aids; poor visibility or Instrument meteorological conditions (IMC) conditions; SOPs intentionally disregarded; aircraft is flown towards the ground with vertical, lateral or speed deviations (unstable approach) until impact.

Section 8—Conclusion

This CFIT accident analysis report examined data from 34 accidents in the period 2010-2014, which resulted in 707 fatalities, thereby making CFIT the second largest fatal accident category after LOC-I. CFIT accidents have a low survivability rate for aircraft occupants, averaging just 19% for the period.

The widespread adoption of TAWS/GPWS technology, and especially GPWS with a forward looking terrain avoidance function like EGPWS, in recent years has led to a significant global reduction in the rate of CFIT accidents. However, there remain some regulatory jurisdictions which either do not mandate or do not enforce the ICAO standards for TAWS/GPWS and operators in these regions are consequently exposed to a higher risk of CFIT.

Human performance was a major factor in many of the CFIT accidents analyzed, usually involving the absence of adequate pilot knowledge, situational awareness or competency in aircraft handling. Operators must ensure that their training and checking programs robustly address these potential deficiencies and the regulatory framework should include processes to effectively evaluate operators' training systems.

State Safety Programs (SSP) and airline SMS offer the overarching structures to identify and manage CFIT risk but they must be constantly tested and improved to remain effective. High risk activities such as poorly designed non-precision approaches at difficult destinations should be eradicated from the operation or actively managed by intelligent risk reducing operational procedures.

By definition controlled flight into terrain *can* be avoided and it is hoped that the content of this report will help achieve that goal.

Section 9—Appendix A – IATA Accident Criteria and Definition

9.1 Type of Operation Criteria

In order for an event to be considered an accident, the flight must be listed as a scheduled or unscheduled passenger or cargo flight, or a positioning flight. All other types of operation (e.g. training, maintenance, etc…) are excluded. Furthermore, single-pilot operations are excluded.

AIRCRAFT CRITERIA

In order for an event to be considered as an accident, the aircraft involved must meet the following criteria:

Jets:

- Maximum Takeoff Weight (MTOW) above 15,000 KG
- Twin-engine
- Turbine powered only

Turboprops:

- MTOW above 5,700 KG
- Twin-engine
- Turbine powered only

Exclusions: cases of contained engine failure or damage, when the damage is limited to the engine, its cowlings or accessories; or for damage limited to propellers, wing tips, antennae, tires, brakes, fairings, small dents or puncture holes in the aircraft skin; or the aircraft is missing or is completely inaccessible; or acts of war, sabotage or unlawful interference are not considered accidents.

9.2 Definitions

9.2.1 Hull Loss

An accident where the aircraft is completely destroyed or will not be repaired (economic write-off).

9.2.2 Substantial Damage

Damage or structural failure, which adversely affects the structural strength, performance or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component.

Notes:

10. Bent fairing or cowling, dented skin, small punctured holes in the skin or fabric, minor damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wing tips are not considered “substantial damage” for the purpose of this Safety Report.
11. The ICAO Annex 13 definition is unrelated to cost and includes many incidents in which the financial consequences are minimal.

9.2.3 Phase of Flight:

Phase of flight: the phase of flight definitions developed and applied by IATA are presented in the following table:

Take-off (TOF): This phase begins when the crew increases the thrust for the purpose of lift-off; it ends when an Initial Climb is established or the crew initiates a “Rejected Takeoff” phase.

Rejected Take-off (RTO): This phase begins when the crew reduces thrust for the purpose of stopping the aircraft prior to the end of the Takeoff phase; it ends when the aircraft is taxied off the runway for a “Taxiin” phase or when the aircraft is stopped and engines shutdown.

Initial Climb (ICL): This phase begins at 35 feet above the runway elevation; it ends after the speed and configuration are established at a defined maneuvering altitude or to continue the climb for the purpose of cruise. It may also end by the crew initiating an “Approach” phase.

> **Note:** *Maneuvering altitude is based upon such an altitude to safely maneuver the aircraft after an engine failure occurs, or predefined as an obstacle clearance altitude. Initial Climb includes such procedures applied to meet the requirements of noise abatement climb, or best angle/rate of climb.*

En Route Climb (ECL): This phase begins when the crew establishes the aircraft at a defined speed and configuration enabling the aircraft to increase altitude for the purpose of cruising; it ends with the aircraft established at a predetermined constant initial cruise altitude at a defined speed or by the crew initiating a “Descent” phase.

Cruise (CRZ): The cruise phase begins when the crew establishes the aircraft at a defined speed and predetermined constant initial cruise altitude and proceeds in the direction of a destination; it ends with the beginning of Descent for the purpose of an approach or by the crew initiating an “En Route Climb” phase.

Descent (DST): This phase begins when the crew departs the cruise altitude for the purpose of an approach at a particular destination; it ends when the crew initiates changes in aircraft configuration and/or speeds to facilitate a landing on a particular runway. It may also end by the crew initiating an “En Route Climb” or “Cruise” phase.

Approach (APR): This phase begins when the crew initiates changes in aircraft configuration and /or speeds enabling the aircraft to maneuver for the purpose of landing on a particular runway; it ends when the aircraft is in the landing configuration and the crew is dedicated to land on a specific runway. It may also end by the crew initiating a “Go-around” phase.

Go-around (GOA): This phase begins when the crew aborts the descent to the planned landing runway during the Approach phase, it ends after speed and configuration are established at a defined maneuvering altitude or to continue the climb for the purpose of cruise (same as end of “Initial Climb”).

Landing (LND): This phase begins when the aircraft is in the landing configuration and the crew is dedicated to touch down on a specific runway; it ends when the speed permits the aircraft to be maneuvered by means of taxiing for the purpose of arriving at a parking area.

It may also end by the crew initiating a “Go-around” phase.

Section 10—Appendix B – IATA Regions

Region	Country
AFI	Angola
	Benin
	Botswana
	Burkina Faso
	Burundi
	Cameroon
	Cape Verde
	Central African Republic
	Chad
	Comoros
	Congo, Democratic Republic of
	Congo, Republic of
	Côte d'Ivoire
	Djibouti
	Equatorial Guinea
	Eritrea
	Ethiopia
	Gabon
	Gambia
	Ghana
	Guinea
	Guinea-Bissau
	Kenya
	Lesotho
	Liberia
	Madagascar
	Malawi
	Mali
	Mauritania
	Mauritius
	Mozambique
	Namibia
	Niger
	Nigeria
	Rwanda
	São Tomé and Príncipe
	Senegal
	Seychelles
	Sierra Leone
	Somalia
	South Africa
	South Sudan
	Swaziland
	Tanzania
	Togo
	Uganda
	Zambia
	Zimbabwe
ASPAC	Australia[1]
	Bangladesh
	Bhutan
	Brunei Darussalam
	Burma
	Cambodia
	East Timor
	Fiji Islands
	India
	Indonesia
	Japan
	Kiribati
	Laos
	Malaysia
	Maldives
	Marshall Islands
	Micronesia
	Nauru
	Nepal
	New Zealand[2]
	Pakistan
	Palau
	Papua New Guinea
	Philippines
	Samoa
	Singapore
	Solomon Islands
	South Korea
	Sri Lanka
	Thailand
	Tonga
	Tuvalu, Ellice Islands
	Vanuatu
	Vietnam
CIS	Armenia
	Azerbaijan
	Belarus
	Georgia
	Kazakhstan
	Kyrgyzstan
	Moldova
	Russia
	Tajikistan
	Turkmenistan
	Ukraine
	Uzbekistan
EUR	Albania
	Andorra
	Austria
	Belgium
	Bosnia and Herzegovina
	Bulgaria
	Croatia
	Cyprus
	Czech Republic
	Denmark[3]
	Estonia
	Finland
	France[4]
	Germany
	Greece
	Hungary
	Iceland
	Ireland
	Italy
	Israel
	Kosovo
	Latvia

Region	Country
	Liechtenstein
	Lithuania
	Luxembourg
	Macedonia
	Malta
	Monaco
	Montenegro
	Netherlands[5]
	Norway
	Poland
	Portugal
	Romania
	San Marino
	Serbia
	Slovakia
	Slovenia
	Spain
	Sweden
	Switzerland
	Turkey
	United Kingdom[6]
	Vatican City
LATAM	Antigua and Barbuda
	Argentina
	Bahamas
	Barbados
	Belize
	Bolivia
	Brazil
	Chile
	Colombia
	Costa Rica
	Cuba
	Dominica
	Dominican Republic
	Ecuador
	El Salvador
	Grenada

Region	Country
	Guatemala
	Guyana
	Haiti
	Honduras
	Jamaica
	Mexico
	Nicaragua
	Panama
	Paraguay
	Peru
	Saint Kitts and Nevis
	Saint Lucia
	Saint Vincent and the Grenadines
	Suriname
	Trinidad and Tobago
	Uruguay
	Venezuela
MENA	Afghanistan
	Algeria
	Bahrain
	Egypt
	Iran
	Iraq
	Jordan
	Kuwait
	Lebanon
	Libya
	Morocco
	Oman
	Qatar
	Saudi Arabia
	Sudan
	Syria
	Tunisia
	United Arab Emirates
	Yemen

Region	Country
NAM	Canada
	United States of America[7]
NASIA	China[8]
	Mongolia
	North Korea

[1]Australia includes:
Christmas Island Cocos (Keeling) Islands Norfolk Island Ashmore and Cartier Islands Coral Sea Islands Heard Island and McDonald Islands

[2]New Zealand includes:
Cook Islands Niue Tokelau

[3]Denmark includes:
Faroe Islands Greenland

[4]France includes:
French Polynesia New Caledonia Saint-Barthélemy Saint Martin Saint Pierre and Miquelon Wallis and Futuna French Southern and Antarctic Lands

[5]Netherlands include:
Aruba

[6]United Kingdom includes:
England Scotland Wales Northern Ireland Akrotiri and Dhekelia Anguilla Bermuda British Indian Ocean Territory British Virgin Islands Cayman Islands Falkland Islands Gibraltar Montserrat Pitcairn Islands Saint Helena South Georgia and the South Sandwich Islands Turks and Caicos Islands British Antarctic Territory Guernsey Isle of Man Jersey

[7]United States of America include:
American Samoa Guam Northern Mariana Islands Puerto Rico United States Virgin Islands

[8]China includes:
Hong Kong Macau Chinese Taipei

Section 11—Appendix C – RASG Regions

RASG Region	List of Countries
Africa-Indian Ocean (AFI)	Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ívoire, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Île De La Réunion (Fr.), Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte (Fr.), Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe
Asia and Pacific (APAC)	Afghanistan, American Samoa (U.S.A.), Australia, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Cook Islands, Democratic People's Republic of Korea, Democratic Republic of Timor-Leste, Federated States of Micronesia, Fiji, French Polynesia (Fr.), Guam (U.S.A.), India, Indonesia, Japan, Kiribati, Lao People's Democratic Republic, Malaysia, Maldives, Marshall Islands, Mongolia, Myanmar, Nauru, Nepal, New Caledonia (Fr.), New Zealand, Niue (NZ.), Norfolk Island (Austr.), Northern Mariana Islands (U.S.A.), Pakistan, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Singapore, Solomon Islands, Sri Lanka, Thailand, Tonga, Tuvalu, Vanuatu, Viet Nam, Wallis Is.(Fr.)
Europe (EUR)	Albania, Algeria, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Faroe Islands (Den.), Finland, France, Georgia, Germany, Gibraltar (U.K.), Greece, Greenland (Den.), Hungary, Iceland, Ireland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Morocco, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, The former Yugoslav Republic of Macedonia, Tunisia, turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan
Middle East (MID)	Bahrain, Egypt, Iraq, Islamic Republic of Iran, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, United Arab Emirates, Yemen
Pan-America (PA)	Anguilla (U.K.), Antigua and Barbuda, Argentina, Aruba (Neth.), Bahamas, Barbados, Belize, Bermuda (U.K.), Bolivia, “Bonaire, Saint Eustatius and Saba”, Brazil, Canada, Cayman Islands (U.K.), Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominica, Dominican Republic, Ecuador, El Salvador, Falklan Islands (Malvinas), French Guiana (Fr.), Grenada, Guadeloupe (Fr.), Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique (Fr.), Mexico, Montserrat (U.K.), Nicaragua, Panama, Paraguay, Peru, Puerto Rico (U.S.A.), Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Sint Maarten (Dutch part), Suriname, Trinidad and Tobago, Turks and Caicos Islands (U.K.), United States, Uruguay, Venezuela, Virgin Islands (U.S.A.)

Section 12—Appendix D – Challenges with Applying Taxonomies

he application of the taxonomy is not always clear-cut between the LOC-I category or some other category (mainly CFIT).

In some cases it is unclear whether the crew first lost control of the aircraft and the flight subsequently ended as CFIT or whether a flight crew encountered a controlled flight towards terrain, realized the situation in last second and subsequently stalled the aircraft in an attempt to avoid terrain.

An answer can usually be derived once the official accident investigation report is available and the sequence of events is determined.